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DISCOVERIES.

DISCOVERIES in Science are the result either of experiment, of thought, or of chance. An experimental discovery is usually the result of a well-planned attack upon some fortress of Dame Nature —every step, every sap, and every battery, being well considered and faithfully followed; or it results from the attacking force perceiving indications of some sunken mine, or unknown treasure, and following it up with care and determination. Davy's discovery of the safety lamp is an example of the first kind. Something was wanted—its requirements were well defined; Nature was asked to supply those wants and requirements, and she was forced by experiment and enquiry to reply. Faraday's discovery of magneto-electricity was of the second kind. He was engaged in solving a difficult and intricate problem; something attracted his attention, he followed it up, traced it out, and was rewarded with the discovery of what ought to be universally called *Faradaism*.

A discovery the result of pure thought must be based on experience. An experiment sets

> ——— "that inward eye
> That is the bliss of solitude"

a-working. The imagination is brought into play. Thought pictures something that should be, and observation finds out that it is. Graham's discovery of dialysis, and of the occlusion of hydrogen by iron, was of this character. So have been the innumerable additions made to organic chemistry by Liebig and his followers. So have been the strides made in the theory of energy by Mayer, Joule, Thomson, Clausius, and others. Experiment has set the ball rolling, thought has kept it going, and imagination has said "If I only direct it in such a path I am sure to alight on some treasure, or it is sure to bring me to the goal I seek."

Discoveries cannot be said to be the simple result of pure chance. Newton and the apple are said to have led to the discovery of gravitation, but the apple was only the means to direct the thoughts of the philosopher in a certain channel, which certainly led to success, but which had been previously pondering and weighing innumerable other channels and courses. Galvani and the frog are said to have led to the chance discovery of voltaic electricity, but the frog may have jerked its legs on the professor's balcony, or skipped in the physicist's laboratory with the energy of a ballet dancer, before it would have led to the discovery of current electricity unless there had been a trained mind to watch its antics, to follow up its peculiarities, and to ferret out its indications.

Daguerre's discovery of the influence of the vapour of mercury upon sensitive plates of silver is another which is included amongst chance discoveries. He had been experimenting on silver plates rendered sensitive to light by iodine, and had after exposure put them by in a cupboard full of chemicals. To his surprise he found, after a time, pictures develope themselves on the plates, attributing the effect to some chemical. He removed the chemicals one by one, until all had been removed. The effect, however, continued. He then found an unknown and forgotten flask of mercury, which gave out its vapour, and thus produced the effect observed,—and this was the origin of the daguerreotype process. But this was not purely the result of chance. It was the previous training and previous experience which arranged the conditions that led to the discovery, and which enabled the mind to seize upon those very facts which resulted in success. Training and experience are therefore essential in seizing upon abnormal indications of Nature, as they are in comprehending and appreciating her laws and in applying them effectively to practice.

THE ROYAL INSTITUTION.

Notes of a Course of Seven Lectures on Electricity.
By PROFESSOR TYNDALL, LL.D., F.R.S.
February—March, 1875.

NOTES OF LECTURE IV. *February* 25, 1875.

(Continued from page 78.)

1. In Experiment (9), Lecture III., it is said that if you touch the sphere under induction "anywhere," the repelled electricity will be discharged. This is readily proved by means of the single sphere employed in (9).

2. It is still more strikingly proved by two spheres mounted on insulating stands—say warm tumblers—and connected by a chain. Bring excited glass jar or tube near one of the spheres; the distant sphere is instantly charged with positive, the adjacent sphere with negative, electricity. A carrier which has touched either ball attracts lath. Touching distant ball it repels rubbed glass; touching adjacent ball it repels rubbed gutta-percha.

3. If the distant ball be touched with the finger, its electricity, as might be expected, flows away to the earth. But the same occurs when the *adjacent* ball is touched. In all cases the *repelled* electricity —and it only—is *free;* and no matter what part of the system under induction is touched, the free electricity—and it only—passes to the earth.

4. The induced electricity of both balls may be shown by means of the straw electroscope referred to in Experiment (10), Lecture II. The short arm of the straw being brought within 4 or 5 inches of one of the balls, the straw is positively electrified.

On placing the excited glass tube which has electrified the straw near the other sphere, the index immediately shows repulsion. Touching one of the spheres, or the connecting chain, with the finger, the free electricity—and with it the repulsion—vanishes. On removing the glass tube the liberated negative electricity produces prompt attraction.

5. The prime conductor of the electric machine is charged by induction. When the glass quits the cushion it is positively electrified. A series of points which forms part of the conductor is commonly presented to the glass. From these the negative electricity streams against the excited glass, and neutralises it. The prime conductor thus becomes charged, not by the accession of positive electricity, but by the withdrawal of negative electricity.

6. The charging of the Leyden jar implies induction. The outer coating being connected with the earth, and the inner coating with the electric machine, the electricity poured into the jar acts inductively across the glass upon the outer coating, attracting the opposite electricity and repelling that of the same name to the earth. Two oppositely electrified layers are thus in presence of each other, being separated merely by the glass. On bringing the inner and outer coatings, by means of a discharger, near each other, before contact is established, discharge occurs in the form of a spark.

7. In the first form of the Leyden jar the hand of the operator formed the outer coating, and the water the inner coating.

8. Instead of glass we may employ any other insulator. Dry air may be employed. Two plates of brass—the one insulated, the other not, with a layer of air between them—constitute a virtual Leyden jar. The arrangement, however, has a name of its own—the condenser.

9. In charging the prime conductor of the electric machine, the charge on the conductor continues to augment up to a certain point, after which it is not augmented by the further working of the machine. If the electricity be drawn away from the conductor, and stored up in a Leyden jar, it requires a greater amount of turning to reach the stationary point. This withdrawal of the electricity by the attraction of a layer of opposite electricity is well shown by the condenser.

10. The nearer the two plates of the condenser are to each other the more complete is the withdrawal, and the thinner the glass of a Leyden jar the more complete is the withdrawal. The force of "condensation" in the Leyden jar was proved by Wilson and Cavendish to be nearly in the inverse ratio of the thickness of the glass.

11. The Leyden jar is sometimes perforated by the discharge of the electricity through the glass. A certain thickness of glass is necessary to prevent this.

12. The influence of the oppositely attractive coating may be well shown by laying a sheet of tinfoil on a table, a plate of glass on the sheet of tinfoil, and a second sheet of tinfoil upon the glass. All being loose, let the upper sheet of foil be connected with a gold-leaf electroscope, and with an electrical machine; turn the machine carefully till the leaves show signs of divergence; then lift the glass and upper coating by means of silk loops. Removed from the condensing action of the lower sheet of foil, the electricity of the upper one diffuses itself so strongly over the electroscope that if care be not taken the ruin of the instrument will be the consequence.

13. Sheets of common block-tin, sheets of paper unwarmed, or plates of undried wood, may be employed in the last experiment, instead of the sheets of tinfoil. With the principle of induction for our guide, we can illustrate in various ways the action of the condenser and of the Leyden jar.

14. Canton found that an amalgam of mercury and tin, mixed with a little chalk or whiting, and applied to the rubber or cushion of the electrical machine, greatly augmented the amount of electricity generated. He was led to this discovery by his experiments on the friction of bodies in pure mercury. The amalgam applied to our cushions is formed of 1 part of tin, 2 parts of zinc, and 6 of mercury, rubbed well together in a mortar, and applied to a cushion or rubber on which a little lard has been smeared. The friction of this amalgam against glass always yields positive electricity, whereas the quality of the electricity excited by other rubbers depends—as shown by Canton—in some measure on the condition of the vitreous surface.

15. The action of the *electrophorus*, introduced by Volta in 1775, is also clearly explained by the principle of induction. The flat surface of an insulator is excited by friction. A flat conductor with an insulating handle is brought down upon the excited surface, which acts inductively upon the conductor. Touch the latter, its repelled electricity passes to the earth. Lift the conductor; it is now charged with electricity opposite in kind to that of the insulator. The process of charging and re-charging the cover of the electrophorus may be repeated a great number of times.

The following memoranda connect themselves with those on the distribution of electricity (25 *to* 29, *and* 37 *to* 42) *of our last lecture*:—

16. Monnier proved that the charge of a conductor depended upon its surface, and not upon its solid contents. An anvil weighing 200 lbs. gave a smaller spark than a speaking trumpet weighing 10 lbs. A solid ball of lead gave a spark of the same force as that obtained from a piece of thin lead of the same superficies, bent into the form of a hoop. Finally he obtained a strong spark from a long strip of sheet lead, but a very small one when it was rolled into a lump.

17. Le Roi and d'Arcy showed that a hollow sphere accepted the same charge when empty as when filled with mercury, which augmented its weight sixty-fold. All this proves the influence of *surface* as distinguished from that of *mass*.

18. The distribution of electricity is well illustrated by the deportment of hollow bodies. Impart successive measures of electricity to the interior of an ice-pail, or a pewter pot. On testing the interior of the vessel with a carrier no electricity is found there, but it is found on the external surface. A hat suspended by silk strings answers as well as the ice-pail.

19. The successive charges may be communicated by a metal ball suspended by silk. The charged ball, on touching the interior surface, becomes, as shown by Franklin, completely unelectric. In making the experiment with the hat, note that the electricity is feeble on the round surface of the hat, but dense at its edges and corners.

20. Franklin placed a long chain in a silver tea-pot, with a silk string at one end. Connecting his tea-pot with a pith-ball electroscope, he produced a divergence. Then lifting the chain by the silk he found that over one portion outside the tea-pot the electricity was diffused, this withdrawal of the electricity from the electroscope being announced by the partial collapse of the divergent pith-balls.

21. The greatest experiment of this kind was made by Faraday, who placed himself in a cubical chamber built of laths and covered with paper and wire-gauze. It was suspended by silk ropes. Within this chamber he could not detect the slightest sign of electricity, however delicate his electroscope, and however strongly the sides of the chamber might be electrified.

Experiments in Lecture IV.

(1.) Two insulated balls, 6 feet apart, united by a chain. Rubbed glass jar placed near one of them, that one found charged with negative, and the distant one with positive electricity.

(2.) Touch distant ball, the positive electricity escapes. Touch near ball, the positive fluid equally escapes, flowing, as it were, *through the captive negative electricity* to the earth. Jar removed; negative electricity found afterwards diffused over both balls and chain.

(3.) Distribution of electricity on cone: charge taken by carrier from rounded apex of cone when tested by electroscope obviously stronger than charge taken from rounded base.

(4.) A brass cylinder (wood covered with tinfoil would answer equally well) presents a point at one of its ends *to* the prime conductor of the electrical machine. Working the machine and discharging the prime conductor, the cylinder is found charged with positive electricity.

(5.) Turning the end with the point *from* the prime conductor and working the machine the cylinder is found charged with negative electricity. In the first of these cases the negative electricity was *drawn* from the point to the positively electrified prime conductor; in the second case the positive electricity was *driven* from the point into the air.

Remark.—The mode of charging the prime conductor described in Note 5, Lecture IV., is illustrated by the first of these experiments.

(6.) Standing on insulating stool, with left hand connected with prime conductor, and sewing needle in right hand, covering the point of the needle with the finger, on presenting hand to the electroscope (4 or 5 feet distant) a very slight action is observed; uncovering the point, the leaves fly violently asunder.

(7.) Mounting a tassel formed of strips of tissue paper on conductor, on turning the machine the strips diverge by mutual repulsion. If the needle with its point covered be presented to the tassel, attraction follows; but the moment the point is uncovered the strips shrink together, and the entire tassel retreats from the point. This illustrates the action of a pointed lightning conductor on an electrified cloud.

(8.) Closing the hand loosely over the needle, long sparks are drawn by the hand from the electrical machine. Causing the point to protrude from the hollow of the hand, no sparks are possible. The broad knuckle or back of the hand, and the finger end, show a similar difference. Presenting the former to the conductor we have dense long sparks; presenting the latter, hardly any sparks at all.

(9.) Take successive measures with a carrier ball (held by a silk string) from prime conductor, or from rubbed glass tube, and put them *into* an insulated ice-pail, a tankard, or a hat. No electricity is found within any of them; but it is found on the external surface of each, from which it may be communicated by a carrier to the electroscope. A mouse within a wire-gauze cage could not be affected by the strongest charge imparted to the cage.

(10.) Franklin's experiment, Note 20, Lecture IV., was made with a small tea-pot and a chain, quadrupled so as to obtain a greater amount of surface. On lifting the chain the gold leaves of the electroscope closed up, on lowering the chain they opened out.

(11.) Cake of resin electrified by fox's brush. Plate of brass with insulating handle placed on the resin. The brass was touched, and the plate lifted. The spark from it ignited a jet of gas.

(12.) A circle of sheet zinc (cut by a pair of common scissors), with a stick of sealing-wax for a handle, makes a very effective electrophorus. Striking a piece of vulcanised india-rubber with fur, and placing the zinc upon it,—on touching the zinc and then lifting it, it is found strongly charged. A half-crown with a sealing-wax handle treated in this way energetically attracts a large balanced lath.

(13.) In all cases the resinous plate, whether it be of ordinary resin, shell-lac, vulcanised india-rubber, or ebonite, proves its electricity to be negative by strongly repelling a rubbed gutta-percha tube. The metal plates, on the contrary, prove their electricity to be positive by forcibly repelling a rubbed glass tube.

(To be continued).

LIGHTNING PROTECTORS.*

By the COUNT DU MONCEL.

Although telegraph lightning protectors are designed for another end than ordinary lightning conductors, they possess a mutual relationship, whereby experiments undertaken for the one are—in a certain measure—applicable to the other. This mutual relation is the preserving action they are called upon to exercise. Now, whether this action is to preserve telegraphic apparatus to which protectors are bound, or buildings upon which they are established, from lightning discharges, it is very certain that arrangements efficacious in one instance will be more or less so in the other. This fact being settled, let us first examine how telegraphic lightning protectors are arranged on a circuit with regard to the protection they are intended to afford.

In a properly constructed telegraph office, the line wire—before arriving at the telegraph instruments—is joined to a "protector," and communication with the receiving instrument is effected through the

* This abridgment was made with the object of furnishing documents to a Commission, appointed by the Préfet de la Seine, to revise the regulations regarding the construction of lightning conductors. Experiments were made at the Administration des Lignes Telegraphiques.

medium of a very fine iron wire, called the *Lightning Arrester*. This may melt under the influence of a tolerably considerable charge of electricity,—thereby putting the line in direct communication with the earth, and isolating the telegraphic apparatus. The connection of the line with the lightning protector is accomplished in front of the "arrester" by means of a branch wire which communicates directly with earth. The lightning protector itself —whose construction is very varied—is so arranged as to present a resistance that may be easily cleared by a strong discharge of static electricity, and yet be sufficiently great to prevent the working current running to earth.

The problem (often studied) respecting the best protecting conditions of telegraph lightning protectors resolves itself into the discovery of such an arrangement as—whilst maintaining a break of continuity in the derivative, and through the "protector" to earth—shall nevertheless permit an easy and quick dispersion of a static electric charge; and it must turn aside such a charge from entering into the receiving instrument, as well as minimise the lateral inductive action experienced on the charge's arrival at the office.

From this simple glance it can be easily understood how, with an electric arrangement just described, the "arrester" may in some fashion serve as a measure of the efficiency of the protector and its branch circuit. It is, indeed, very evident that the greater the protection afforded by the "protector" the less length of wire (composing the arrester) will be melted.

The following are the results of experiments on this question instituted at the "Administration of Telegraph Lines:" they were carried out by help of the large Ruhmkorff coil charged to a maximum with a six-element Bunsen battery, and with a battery of six large Leyden jars:—

1. When the discharge traversed the arrester only (a fine iron wire 1-15th of a millimetre in diameter), it was melted for a length of from 50 to 60 centimetres.

2. When the discharge was bifurcated, one portion through the "arrester" and the other through the "protector," the length of melted wire varied according to the condition of the circuit and the kind of lightning protectors experimented upon.

3. With short circuits, and when no extraneous cause intervened to retard the discharge, the influence due to a particular arrangement of lightning protectors was insignificant, and their protecting power was equal to that of the derivation in which they were placed. They acted then as if this wire preserved its metallic continuity. But such was no longer the case when the circuit presented a certain resistance, or when the discharge was retarded by any means whatever. A retarding effect always takes place during lightning discharges, since the discharge has to pass through a layer of air or clouds more or less thick, and through metallic resistances more or less great.

4. When, by sufficiently retarding the discharge so as to melt the "lightning arrester" for a length of 15 millimetres, and with a communication *direct* to earth through the branch wire, the effect of introducing a protector into the derivation increased the length of the melted portion from 2 to 9 c.m., according to the description of "protector."

5. With "*plate* protectors" (two metallic plates separated by a sheet of mica or gutta-percha) the length of wire melted varied from 20 to 30 m.m. inversely as the surface of the plates.

6. With a "12-*point* protector the effect was almost the same as in No. 5. But on reducing the number of points to 6, the "arrester" was fused for a length of 4 c.m.; and with all the 12 points blunted, from repeated discharges, fusion took place for a length of 4 to 5 c.m.

7. The preserving action of "*point* lightning protectors" is thus found to be variable in proportion to the number of points and their disposition. Under good conditions their conserving power increases with their number, although generally only one very intense spark is observed at each discharge; but when they are placed in unfavourable conditions their multiplicity is often hurtful, and, with "protectors" of the "point" class, the "arrester" then melted for a length of from 4 to 9 c.m., according to their arrangement.

8. We equally recognise that the number of points necessary to render a "protector" thoroughly efficient must vary according to the degree of their sharpness and size. When they are very sharp and fine their distance apart may be advantageously reduced to a lateral distance of 2 m.m., but if of ordinary size—say that of a stout pin—5 m.m. will be the best distance between them. The separation of the two plates is regulated inversely by analogous conditions; the finer and sharper the points the less necessary for them to approach. The best distance is, nevertheless, 1 m.m.

9. As the action of "protectors" is complex, and since they are intended not only to ward off atmospheric electrical discharges, but also to slowly diminish the tension of storm clouds, it is requisite to examine the question from this latter point of view. We know, from numerous experiments, that *point* "protectors" have, in this latter respect (power of diminishing the influence of storm-clouds), a marked advantage over other systems, although *plate* "protectors" are—as far as can be observed—generally more efficacious with regard to protection. Thus, if the conductor of an electric machine is put to earth through a "protector," the electroscopic effect is noticed to much weaken when a point protector is used, whilst it retains a larger value when a *plate* protector is employed. These facts thus indicate that telegraph lightning protectors should consist both of *plates and points*. The plate system will protect against the lightning-stroke; the point system will weaken the electric influence of storm-clouds.

Having studied the influence of lightning protectors with regard to telegraphic circuits, there yet remains to be examined the influence exercised by earth conductors. Experiments made on this subject led to perfectly unforeseen results. Reasoning upon M. Gaugain's and other physicists' researches, we ought to conclude that static electricity should follow (in its course along metallic conductors) the well-known laws of voltaic currents; consequently it should be admitted that thickness of section of metallic conductors, intended to lead electric discharges to earth, ought to exercise an influence determinable by Ohm's laws. This, indeed, takes place when we experiment with streams of static electricity that have attained their permanent condition; but in the variable period of their transmission their potential is not a maximum, and,

as a lightning-discharge is precisely under this latter condition, it is not astonishing when experiments indicate totally different effects. Now, it has been shown, from some very curious experiments undertaken by M. Guillemin, that the rapid dispersion of an electric charge (after an explosion) depends principally on the *surface* of the conductor leading to earth. *Thus a simple strip of tin exercises a much greater protective action than an iron wire of large diameter*, with a section much more considerable. I had already convinced myself that currents of static electricity in transit through metallic conductors, even copper, encounter a far greater resistance than do voltaic currents; and that they often have greater facility in clearing a break of continuity than in following a metallic circuit, though even a very short one. Thanks to this property, I succeeded in confining—in two different circuits—the inverse and the direct currents of Ruhmkorff's apparatus.

The conclusion of these experiments was, then, that wires connecting lightning protectors with earth should be substituted by metallic strips. The following is the verdict of the Commission for the Improvement of Telegraphic Material on this subject:—"The earth communications of lightning protectors ought to be established by means of copper strips, 4 to 5 centimetres wide, and 1 millimetre (or less) thick. The conductor should communicate with damp soil by means of a metallic plate of at least 1 square metre surface: such a conductor suffices for the wants of a line of 5 or 6 wires."

From the theoretic and experimental studies of Messrs. Kirchoff and Smaasen, respecting the conductivity of indefinite conductors, it results that—if a telegraphic line traversed by a current is put to earth (at its free end) by the medium of a metallic mass, whilst the battery supplying the current communicates with earth in the same manner—*the resistance of the earth between these two metallic masses is independent of the distance separating them, and varies only with their surface contact*. This VARIATION IS INVERSELY AS THE SQUARE ROOTS OF THESE SURFACES. The deduction to be obtained is that we should establish, as much as possible, electric connection with earth, by means of *the largest possible* metallic plates.

In my recent researches on the conductivity of ligneous bodies I had (on more than one occasion) not only to recognise the truth of this principle, but to verify Kirchoff's conclusions which led up to the law previously formulated.* In addition, here is another experiment, undertaken since the commencement of my researches on Electricity, and which everyone may understand, on account of its simplicity:—Desiring to directly determine, for electric bells, the minimum dimensions suitable for earth-plates when earth formed part of the circuit, I took a Daniell's battery of 8 elements, and, having rolled upon two wooden cylinders (in open spirals) some 3 m m. diameter galvanised iron wire, I put them in connection with the circuit of the bell. I then immersed, in two different parts of a pond, one of the extremities of each of these two cylinders. Then the cylinders were plunged successively into the water until the electric bells worked. Now I ascertained that to obtain this effect at a distance of 10 metres between the two cylinders, the immersed length of wire should be 34 metres,—*i.e.*, the metallic surface should present at least 32 square decimetres. At a less distance this surface might be reduced, but it sufficed for a greater distance; thus showing that beyond 10 metres the direct conductivity of liquids vanished in the general conductivity of the earth. Later experiments have, moreover, demonstrated that—under ordinary conditions of telegraph lines—the earth's resistance to electric diffusion averages *four thousand metres of telegraph wire*. To overcome resistances of this kind, metallic contact surfaces—larger than those which earth connections of ordinary lightning-conductors possess—are therefore required.

Ordinary earth connections of lightning-conductors are not thus generally regulated. They are often made through kinds of arrows, or iron forks, under the idea that they would facilitate in this manner the dispersion of the conductor's electric charge. It is easy to see that, if such has been the motive, a double error has been committed:—first, because the soil does not behave like an aëriform medium of so small conductivity as air; secondly, because the charge of the conductor of lightning-protectors comes oftenest from the earth.

In Telegraphy preference has always been given, especially in dry ground, to metallic plates; and the want of conductibility in these grounds has been supplied by increased surface of the plates, placing them in the neighbourhood of gutter- and eave-pipes, and taking care to surround them with a sandy or percolating soil. Nevertheless preference is always given, and rightly so, to wells, sheets of water, and water conduits.

As to the conductors communicating with these plates, the metallic strips appointed by the "Commission of Improvements" have been generally supplanted by galvanised iron wire cables, each wire being 3 m.m. diameter. These cables contain as many strands as there are line wires leading to the station, and for certain important offices there may be as many as 150 of them. By this means a great development of metallic surface is obtained, and the construction of these conductors thus becomes easier and less onerous. Perhaps, with this arrangement, there might be reason to fear induction of the wires upon each other,—an effect that might somewhat retard the speed of the electric flow; but, as in a good manufacture (*fabrication*) the strands should touch one another, this action is after all to be little dreaded. It is, however, important that the metallic surfaces should be as clean as possible; hence recourse has been had to galvanised iron.

* These articles appeared in the TELEGRAPHIC JOURNAL, vol. ii.

POST-OFFICE TELEGRAPHS.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 17th April, 1875, and during the corresponding week of 1874:—1875, 402,903; 1874, 370,865; increase in the week of 1875 on that of 1874, 32,038.—Week ended 24th April, 1875, and corresponding week of 1874:—1875, 391,403; 1874, 374,056; increase in the week of 1875 on that of 1874, 17,347.

THE WARRANTS for the dividends on the Ordinary and Preference Shares, declared at the last General Meeting of the Direct Spanish Telegraph Company, Limited, —payable when the balance of the messages accounts to the 31st December, 1874, was received,—were issued on the 27th ult.

NOTES ON MR. EDISON'S ELECTRICAL PROBLEM.

By OLIVER HEAVISIDE.

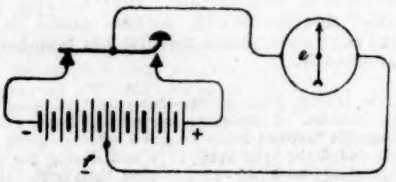
In the TELEGRAPHIC JOURNAL for January 15, 1875, Mr. Thos. A. Edison submitted the following problem to its readers for solution:—"Transmit alternately positive and negative currents within a closed circuit from a battery all the poles of which are connected in the ordinary manner, using an ordinary Morse key, to which no extra point or appliances whatever is to be added. No device other than the battery, key, and connecting wires is to be used."

None of the readers of this Journal have as yet come forward with any solution. Why is this? It is certainly not because there is nobody in the British Isles who takes an interest in such matters, and I can only suppose that an excess of modesty has prevented many of the readers of this Journal from sending a solution for publication. As the problem is of a highly interesting nature, I think it should not be allowed to drop out of mind, and so send a few remarks on the problem and its solution. Perhaps others will then come forward with improved methods.

The practical telegraphist who has been accustomed to the use of the Morse key for sending single currents, and a "double-current" key for sending reversed currents, will probably be inclined, on a first perusal, to consider the problem a sort of electrical conundrum, not admitting of any legitimate solution; but such is certainly not the case. I must, however, in the first place, point out that it is an impossibility on the face of it to reverse the current in a *closed circuit* containing a single battery all the poles of which are connected in the ordinary manner: the current in the battery itself has necessarily always the same direction, and a second battery of greater strength would be required to reverse the current in the first. All we can do is to reverse the direction of the current, in some or all of the conductors, in the circuit which lie outside the battery. I assume, therefore, that this is what Mr. Edison means is to be done, and on this assumption we can proceed further with the problem.

The restriction contained in the enunciation that all the poles are to be connected in the ordinary

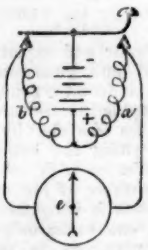
Fig. 1



manner, I take to mean that the battery is to be joined up "for intensity," to use the convenient old-fashioned phrase; that is to say, the positive pole of one cell is to be connected with the negative pole of the next, and so on all through the battery. This restriction, however, does not forbid us to make a connection by means of a wire between our Morse key and any intermediate pole of the battery, as this will not interfere with all the poles being connected among themselves in the ordinary manner; hence we have the following arrangement, answering every condition of the problem (Fig. 1). The battery *f* has its two terminal poles connected with the back and front stops of the key respectively, and any intermediate pole is connected through the external resistance, *e*, with the lever of the key. This will obviously produce alternately positive and negative currents in the external resistance when the key is worked, and is too simple to require any further explanation. This system was in use many years ago for signalling on underground or submarine wires, and may possibly be still used.

It will be observed that in the above system the whole battery is never in circuit at once; in fact, we are practically employing one battery for the positive currents and another for the negative. If we wish to employ the whole battery both for positive and negative currents we must seek some other plan. Mr. Edison lays no restriction on the *resistance* of the connecting wires, so that, practically speaking, he allows the use of resistance coils. This contradicts the statement in the problem that no device other than the key, battery, and connecting wires is to be used, but we may produce harmony again by uncoiling the wires of the resistance coils. Or, if we have a galvanometer of sufficient delicacy, we may use short pieces of wire. Fig. 2, then, shows

Fig. 2



a second solution of the problem. The external resistance, *e*, is connected between the back and front stops of the Morse key; one pole of the battery is connected with the lever of the key, and the other with the junction of two wires, *a*, *b*, the other ends of which go to the back and front stops of the key. When the key is in the position shown in Fig. 2 the current from the + pole of the battery divides so that the greater portion goes through *b*, and the remainder through *a* and *e*, to the back stop of the key, and so to the − pole of the battery. When, however, the key is depressed, so that the lever is in contact with the front instead of the back stop, the current from the + pole divides so that the greater part goes through *a*, and the remainder through *b* and *e*, to the front stop of the key, and so to the − pole of the battery. The current is thus reversed in *e*. It is obvious that we can give any relative strengths to the + and − currents in *e* by suitably changing the resistances of *a* and *b*, and that when *a* and *b* are equal the reversed currents in *e* are equal. The galvanometer, *e*, may of course be replaced by a line. The currents sent to line will naturally be less than if the battery were connected direct to line, as in the ordinary double-current key. How much less we must cal

in the aid of Ohm's laws and algebra to determine. Let E be the current in the line, P the electromotive force of the battery, f its resistance, and a and b the resistances of the two wires. Then when the lever of the key rests on its front and back stops, the currents sent to line are—

$$\frac{Pa}{f(a+b+e)+a(b+e)} \text{ and } \frac{Pb}{f(a+b+e)+b(a+e)}$$

respectively; and when $a=b$ each of these becomes—

$$E=\frac{P}{\frac{ef}{a}+a+e+2f} \quad . \quad . \quad . \quad . \quad (1)$$

To have as strong signals as possible with any given line and battery we must make E a maximum subject to the variation of a. Now the denominator of (1) is a minimum when $a=\sqrt{ef}$; therefore E is then a maximum, and its expression is—

$$E=\frac{P}{2\sqrt{ef}+e+2f}.$$

Let us take a numerical case. Let the resistance of the line, including the apparatus at the other end, be $e=5000$ ohms, the battery resistance $f=50$ ohms, then $a=\sqrt{50\times5000}=500$ ohms, and—

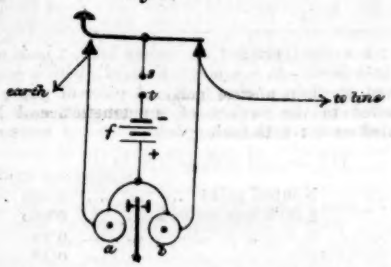
$$E=\frac{P}{2\times500+5000+2\times50}=\frac{P}{6100}.$$

Now, if the battery were joined direct to line, the total resistance in the circuit would be 5050, and the current would be $\frac{P}{5050}$, which is greater than the former result in the proportion of 6100 to 5050; so that the plan of signalling reversals as in Fig. 2 would be attended with a loss of strength of current amounting to about $\frac{1}{6}$ in this particular case. This difference is not very great, but a further disadvantage is that the battery is much harder worked in the system of Fig. 2 than in the ordinary system. These disadvantages would, no doubt, effectually preclude the use of the Morse key for signalling reversals by this particular arrangement; but, on the other hand, it may be adapted to form a system of signalling reversed currents having some advantages over the ordinary method. The principal points of this plan are as follows:—

(1.) The reversals are produced by a Morse key.
(2.) The sending station works his own instrument, so that he may hear or register his signals at pleasure.
(3.) Each station can interrupt the others' sending.

Let the two resistances a and b, in Fig. 2, be the two coils of a Siemens relay, or any other polarised receiving instrument; replace the galvanometer e by the line, and put the front stop of the key to earth. Then we have the arrangement shown in Fig. 3, where the two points s and t may be joined or separated by means of a switch, or any other contrivance. When they are joined and the key is worked reversals are sent to line, just as in Fig. 2 reversals are sent through e. The currents sent split unequally between the two coils a and b, most going through one coil when the key is depressed, and most through the other coil when it is elevated, and the consequence of this unequal alternate division of the current will be that the armature of the instrument will exactly repeat the movements of the key. This is point (2). When it is desired to receive, separate s and t by means of the switch, and the battery will be cut off, and all received currents will pass through both coils in the *usual* manner. Furthermore, as stated above,

Fig. 3.

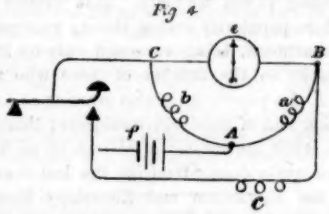


the receiving station can interrupt, for the sender's signals will then be no longer correctly repeated by his own instrument. Possibly Mr. Edison is perfectly well acquainted with this extension, or rather application, of his problem, to the discussion of which we may now return.

If, in the arrangement in Fig. 2, we make the battery and galvanometer change places, we get another—though somewhat similar—method of sending reversals through e. If e is greater than f the currents will be weaker, but if f is greater than e they will be stronger. Otherwise this arrangement is so similar to Fig. 2 as to call for no further comment.

In the previous three methods both stops of the key have been used. In the following only one is used. In Fig. 4, e is the galvanometer or other re-

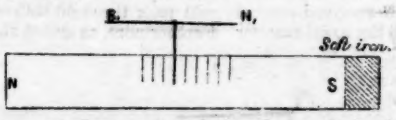
Fig 4



sistance through which reversals are to be sent; a, b, and c are three resistances; and f the battery. The back stop of the key is not connected with any part of the arrangement. When the key is at rest the current from the + pole divides at A, through the two roads A C B and A B, which join at B, and the circuit is completed through c. When the key is depressed the current divides both at A and at B, and the current in e is reversed. We may also change the positions of the battery and galvanometer in Fig. 4, and still have reversals in the galvanometer. No doubt there are other methods, more or less simple, of obtaining reversals in a conductor by means of a Morse key, and, now that a beginning has been made, they ought to pour in from all parts of the United Kingdom. Mr. Edison's own solutions would also be very acceptable.

THE NEUTRAL LINE OF MAGNETS.

The following experiment was made to determine whether the position of the neutral line in a magnet was shifted by lengthening it by pieces of soft iron attached to it as armatures :—



N S a steel magnet 12 inches long, 1 inch wide, ¼ inch thick. N, S, a magnetic needle with a pointer fixed at right angles to it. A piece of paper was pasted to the surface of the magnet, and lines ruled on it 1-10th inch apart.

(1st magnet with no iron to it.)

	Distance from centre.
Neutral point	0·025
¾ inch iron on end	0·050
¾ " " "	0·10
1¼ " " "	0·18
3 " " "	0·25
6 " " "	0·35
12 " " "	0·38
18 " " "	0·40

The iron was of the same section as the magnet. It thus appears that the position of the neutral line does shift.

Notes.

An exceedingly interesting lecture on Science-teaching was given by Dr. Gladstone on Friday evening, April 16th, from which we learnt that the number of classes for Magnetism and Electricity in the United Kingdom, in 1874, was 448, comprising 11,605 students. This subject stands second in popularity among the 23 recognised by the Department, being exceeded only by Physical Geography in the number of those who wish to study it. Its popularity is also growing at a greater rate than that of most other subjects; thus, for instance, while the number of classes in all subjects has not quite doubled during the last four years, those for Magnetism and Electricity have risen from 170 to 448, while six years ago there were only 59 classes. It is also a favourite in the training colleges for elementary schoolmasters. In England it is taught in seven of these colleges to 286 students, and in Scotland—in the two principal colleges—to 170 students. If we add to this the teachers' Science classes at St. Thomas's, Charterhouse, where 103 learnt Electricity and Magnetism in 1874, we have the large number of 559 students who are, or intend becoming, teachers themselves. Besides this, the subject is taken up by a great many pupil teachers, and is taught in some of our best elementary schools; for instance, in the Model School in the Borough Road, and the Practising School at St. John's, Battersea. There were about forty schoolmasters who attended the practical class at South Kensington last summer, and learnt to make such simple and inexpensive but effective apparatus as was exhibited on the table.

A telegram has been received that Mr. F. C. Webb, in the *Ambassador*, has succeeded in laying the Platino-Brazileira cable for Messrs. Siemens Brothers. The last section, from Rio Grande to Chuy, has just been completed, and the *Ambassador* returned to the River Plate for coaling. It is understood she will make an endeavour to recover some of the cable lost with the *Gomez*.

The Indo-European Telegraph Company announce that the average time in transit between London and India *viâ* Teheran, of all outward messages, during the week ending 23rd April, was 1 hour 13 minutes.

The Anglo-American Telegraph Company announce that on and after the 1st of May the rate for messages will be *two* shillings per word.

An announcement is daily expected of the completion of the Direct United States cable. The *Faraday* left on the 5th of April, and is now supposed to be at work on the ground off Newfoundland.

The *Dacia* has been signalled on her outward passage. She has on board about 700 miles of cable for connecting the South American Pacific Coast. She will be shortly followed by another steamer. The *International*, engaged in the same work, has some time since left.

Proceedings of Societies.

THE TELEGRAPH ELECTRICAL SOCIETY, MELBOURNE.

(Concluded from p. 35.)

I might pass over the second question, "What is the use of such a Society?" by simply saying that the objects above stated *prove* the utility of the Society; but a little more may be said on the subject. A good *practical* telegraphist might say, "Why not leave these things to men of science? So long as we can work *their inventions* to *their* satisfaction, and to the satisfaction of our superiors, what need have we to put ourselves out of the way to learn what we can probably very well dispense with?" To that question I would answer, that, if any one has no objection to working like a mere machine, no one has any right to interefere with him. I would be sorry to see any one join this Society against his inclination. A man-machine is a very useful machine, not always as useful as an inaminate one, but possessing some advantages which the latter does not. Now, I do not mean in the least to say, or to imply, that those members of the Telegraph Department who do not join this Society are machines, but I do say, that this Society will be an

excellent means of preventing many of its members from quietly subsiding into that unenviable condition. I, myself, cannot help feeling that there is an actual necessity for me to join a movement of this description in order to prevent myself degenerating, so far as office work goes, into a mere machine; and by devoting a small portion of our spare time to the study we propose, I believe that we will improve our standing as telegraphists very materially. I also think that it is due from us that we should establish a Society of this description in the chief city of Australia, or, I suppose I may say, of the Southern Hemisphere; and should we be successful in the working out of the objects of this Society, a body of efficient practical and theoretical telegraphists will be formed, of the *utility* of which, depend upon it, there will be *no doubt*, and the demand for which will never fail.

This brings me to the last question, "How will the Society be worked?" To that the answer can scarcely be so explicit as to the two first questions. We do not as yet know our strength, either intellectually, numerically, nor financially. But as we may hope to have a sufficient number of members to keep the Society at any rate alive, it will be worth while to devote a few minutes to the consideration of how we may carrry on the work we propose to accomplish. First, as we have already agreed, by the reading of papers contributed by the members, and by discussion thereon. I need scarcely say that it will not be necessary that these papers should be orignal, either wholly or in part, so long as the reader is honest enough to give the name of the author. We may come to that in time, but at present I incline to think that in most cases the less originality there is about the papers, the more solid instruction they are likely to contain. In this paper, with which I am taxing your patience to-night, originality is of course essential, as it treats of no scientific facts, but simply of the establishment of a new and original Society, and therefore I regret I have had very little opportunity for anything like plagiarism. I would suggest that the papers read be more numerous than long. I think that after a few examples of what the papers should be like, but few of the members will find any difficulty in contributing their share. Should, however, the contributions of papers fall short, it will be easy for the Committee to fix upon any subject for discussion, the text-book being some well known work on Electricity. While the papers are being read, those members who wish to profit by them will no doubt take notes. This taking of notes is a most important matter. Mr. W. H. Preece in his lecture makes a special point of it. He says:—"You should always carry with you a note-book, in which everything fresh, everything striking, should be at once jotted down, and there secured as food for reflection. You will thus habituate yourselves to the most invaluable method of fixing upon your minds facts which will be of subsequent use to you. Unless difficulties are recorded when they are met with, or new ideas seized upon and noted down at once, they are apt to escape the memory altogether. I recommend you strongly to write your notes neatly and carefully, and not to destroy them; if they are written on the same sized paper and kept together under their proper subjects, they will prove a never failing source of pleasure." In addition to the reading of papers, it may be at times found advantageous for the members of the Society to meet at the Telegraph Office in order to see practically demonstrated some fact brought before them. I anticipate no difficulty being thrown in our way to such a proceeding, and I may say that I believe this was one reason why the admission of members was restricted to the Post and Telegraph Department. Were strangers admitted, there might possibly be objections raised to their being allowed access to the Telegraph Operating Room.

There is a branch of knowledge which will be found necessary to the student of Electric Science, and which will require special attention on the part of those to whom it is not familiar. I allude to mathematics, and I cannot do better than once more quote Mr. Preece on this point. He says:—

"Mathematics is one of the mind's most valuable assistants. It only needs interpretation; its name frightens. The word mathematics has an alarming sound. Algebra, trigonometry, and the differential calculus are terms that inspire terror into the minds of the uninitiated. But each of these subjects, if energetically grappled with, proves to be so simple that, after once the stile has been crossed, you look back and smile upon the difficulties which apparently encumbered the path, but which existed chiefly in the imagination. . . . No one should be deterred by the letters and symbols which are used to designate mathematical processes, and particularly those who are so used to arbitrary symbols as telegraphists. *Geometry and Algebra are indeed essential* to the skilled telegraphist, and it is difficult for any one to comprehend the higher branches of his profession until he has mastered the elementary principles of these two branches of pure mathematics. It is the application of algebra which enables the telegraph engineer to tell the distance of a fault in a submarine cable to within half a mile, and to direct the sailor, with unerring accuracy, to the spot where he must apply his repairing apparatus. It is trigonometry which enables the sailor by the observation of the sun and stars to direct his ship, though in the middle of the ocean and far away from lands, to this very spot. It is the differential calculus which enables the electrician to obtain the greatest possible speed of working with the least consumption of materials out of his submarine cable."

Another important point to be considered is that of mutual help. Of course there may be always some few who can get on well enough by themselves, but I think that when anyone becomes a member of a Society of this description he is bound to a certain extent to adapt his strength to the average strength of the Society. We are not now preparing to start for a RACE, but for a JOURNEY, and we may have some very rough ground before us. Let us make up our minds to mutually assist each other over any difficulties we may find on the way, and let us make this Society take the place of the *cord* with which Alpine tourists fasten themselves together, and which, though perhaps checking the more rapid advance of some individuals of the party, proves on many occasions the means of a safe journey to the whole of them.

To return to the practical working of the Society, I may say that I think that for the present we will have to confine ourselves to a great extent to the means we have ready to hand, and will have to leave experiments alone until we become stronger in finance. But we have a great deal to learn without even going outside our own office in search of novelties. How few of us, for instance, could set a Wheatstone instrument right if anything went wrong with it, simply because we have never taken the trouble to ascertain the theory of this instrument. There is again the Duplex system of Telegraphy, which I remember thinking, some few years ago, was a wild impossibility, yet which I hope, before long, we will have explained and practically demonstrated to us by one of our members who has devoted a great deal of his time and attention to this problem. Seeing this and other problems practically demonstrated at the Telegraph Office will be one of the advantages of our having restricted the admission of members to the Post and Telegraph Department. In the matter of books, I am happy to say that we have received such assurances of support and encouragement from the heads of the Telegraph Branch, that I believe our slender finances will not be called upon to

provide these necessary auxiliaries, but that the Department will be able to let us have the use, under certain restrictions, of any works which we may consider necessary for the prosecution of our studies. In the same way, I believe that we shall experience no difficulty, perhaps, in having access (of course under restriction) to many useful instruments now in Mr. Ellery's possession or care.

I would also suggest that, as some of the members may be rather backward in even the rudiments of the theory of Telegraphy, we should have, for those who care to attend them, fortnightly meetings (alternating with the Ordinary General Meetings), which might be held in a room of the Telegraph Office, and at which some member, I am sure, could always be found who would be willing to impart to others what knowledge of Telegraphy he may have beyond what the others possess. In this manner we all could be brought up to a more even standard of knowledge of Electricity than exists among us at present, and in a short time the stronger men of science would not find their weaker comrades act as an incubus on them, but they could all go on steadily together.

It only remains for me to point out how country members may assist in working the Society. There are over a hundred country stations. If we can induce (say only sixty) country members to join the Society, I believe we would be able to publish half-yearly a journal containing not only the transactions of the Society, but much other matter (extracted from various works and journals to which we hope to have access), which country members would otherwise never meet with, and which I feel sure will be, to them, fully worth the small subscription they are asked to contribute, even were not the knowledge that by so contributing they are raising the status of the body to which they belong a sufficient inducement to them to join the Society. It is to the country members, then, that we must look, if we are to make this movement anything more than a local one, as it is extremely doubtful if a sufficient fund would be obtained, by the subscriptions of town members alone, to enable the Society to disseminate throughout the whole Department the information they hope to gather by their labours. I feel, however, that I have occupied your time more than sufficiently. I hope that, having once got over the difficulty of starting these meetings, we will spend them more profitably than by reading such papers as I have produced to-night. It was due, however, to the first meeting that something of this sort should be gone through. It is a first push, though perhaps a rather rough one, to the Telegraph Electrical Society, and, thanking you for the patient attention with which you have honoured me, I will conclude by hoping for the Society every possible success.

Some discussion among the members ensued, and a vote of thanks was unanimously given to Mr. L. S. Daniel for his paper.

Notices of Books.

A New Method of Signalling on Railways. Invented and Patented by Sir David Salomons, Bart.

Sir David Salomons, "many years since, struck by the numerous disadvantages which exist in the present mode of signalling on railways," has come to the rescue with a will. His invention consists of laying down a third or centre rail of a smaller gauge than that used for the regular traffic. This rail is divided into sections, according to the requirements of the service, much in the same manner as is now done under the block system. The piece of metal belonging to each section overlaps, and lies parallel to, and on the same level with, but insulated from, that applying to the section in its rear, for a distance sufficient to admit of a train pulling up within the overlapping portions. Under the engine are two metal wheels, borne on one axis, but insulated the one from the other, and both from the engine. These wheels are gauged to run upon the overlapped portion of the signal rail. As this signal rail forms, excepting at the overlapped portion, a continuous line central to the ordinary metals, it is evident one of the wheels affixed to the engine will always be upon it; whilst the other will, at certain points—viz., the points of division of the sections—be upon the overlapped portion of the section in advance.

On the engine is an indicating trembling bell and a battery. One pole of the battery goes to earth by way of the engine. The other pole is connected to that wheel which traverses the continuous line formed by the signal rail. One side of the bell is connected to earth; the other side to that wheel which makes contact with the overlapping portion only of the signal rail. Thus, when a train arrives at the overlapped portion of the signal rail, whilst a train is in the section in advance, the battery current from the engine in advance will flow along the insulated signal rail to that part where it overlaps the section in its rear, and here the wheel in connection with the bell being in contact with it, it will pass through the bell to earth. In passing it rings the bell, and moves an indicator in the direction "train in front." The signal having thus been received, the train in the rear pulls up as quickly as possible, taking care to be within the overlapping portion, otherwise the signal is not received. For the sake of giving early information to following trains, it is also necessary that, in pulling up, it should stand on this portion, which is really the ending of the one and the beginning of another section. By the aid of an additional coil in circuit with the battery, the bell and indicator can be actuated not only by a train in advance, but also by one in the rear; that is, it registers the incoming current from the train in front, and the outgoing current to the train in the rear. There are thus three indications to the one side "train in front;" to the opposite side, "train in rear;" and "bell ringing, but needle vertical, train in rear and in front."

By an application of a modified "Morse" printing instrument, a check is to be kept on the movement of the train; when it stops; when it starts; how long it stops; what signals are received and when, with many others. Sir David even goes so far as to propose a miniature "donkey engine" for the motive power in this arrangement, as it is probable the force of a spring would be exhausted before an engine had fulfilled its whole journey. Further, each guard is to have means of communicating with the driver; the passengers with the guard if requisite. Station agents are to be able to communicate by signal with trains in their sections. Junctions are to be worked by "clerks" placed in offices into which the signal metals are led by wires, so that the entry of a train into the junction section may be ascertained at any moment; that thus certain trains may be stopped whilst others are brought on. In like manner trains are to be started from big stations, by clerks posted in an office for that purpose. The electric current received from a train in advance is to cut off the steam, and thus automatically aid in bringing the train to a standstill. Indeed, it is difficult to see the end of Sir Daniel's invention, so vivid is his imagination, and so enterprising his spirit.

We are afraid Sir David Salomons will find very much more difficulty in bringing his idea into practical working than in designing it. Platelayers are not the sort of men to maintain good an insulated rail, and yet it is evident it must be entrusted to them; for we know how frequently sleepers have to be replaced,

and how uncertain it is when this has to be done. But if, with all the experience of our telegraph engineers, our ordinary telegraphs fail at times through the humidity of our atmosphere, how does Sir David think he will secure the insulation of his rail? True, he says it may be placed at the side of the train, or even overhead, but surely the former would be found but a slight improvement, and very inconvenient; whilst, as regards the latter, we must admit our inability to see how it can be practically carried out. For such a scheme, the "four foot six" is the place, but in what condition the communication would be, and in what state the minds of the officials of the line would be during foggy weather, or during a thaw, can be but too well imagined by those experienced in such matters. Absence of signal is in this system held to be security. To fear it is a *security* which would in the end lead to *danger*.

In part III. of his work, Sir David gives a somewhat lengthy list of *disadvantages* of the present system of signalling, some of which appear to us scarcely well considered. For instance, "the difficulty of distinguishing colours when the eye is tired"—"the non-observance of signals by drunken, careless, or fatigued engine drivers"—"colour blindness of the driver." Sir David should surely know that "colour blindness" is one of the most important points upon which candidates of all classes for railway employ are examined and tested. The difficulty of distinguishing colours when the eye is tired scarcely applies to men in the position of an engine driver; whilst judging from our own experience no class of men, as a rule, are more carefully observant of their duties, or sensible of their onerous character than engine drivers. How it is possible for Sir David's inventions to reduce the dangers of landslips we are at a loss to see; nor can we agree with his conclusion that the system proposed by him would reduce the danger to which men are now exposed when working on the line; increase the dividends of the shareholder, and *decrease* the responsibility of the directors. It is a wild and Utopian idea, and has frequently been proposed before.

Correspondence.

ELECTRICAL PUZZLE.

To the Editor of the Telegraphic Journal.

SIR,—In your Journal of Feb. 15 is published a note from Henry C. Mance, regarding a formula for finding the combined resistance of the derived circuits forming a "bridge," in which it is stated that this problem has been solved without the aid of "Kirchhoff's laws," in a paper communicated to the Royal Society in 1871.

I take the liberty of enclosing a communication from me, published in the *Journal of the Telegraph*, of January 1st, 1875, showing how this result is attained by a process original with me as far as I know. If it differs essentially from that alluded to by Mr. Mance, it may be of interest to your readers as that would be to me.—I am, &c.

A. S. BROWN.

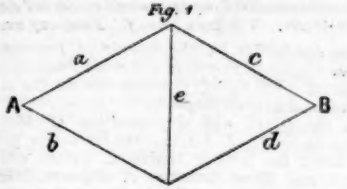
Western Union Telegraph Company,
Superintendent's Office,
New York, March 8, 1875.

From the Journal of the Telegraph, January 1, 1875.

The solutions of the problem of the combined resistance of bridge circuits, furnished by Messrs. Hamilton and d'Infreville, are correct as published in the Journal. The London TELEGRAPHIC JOURNAL also published the same solution of this problem. All of these are based on what are known as Kirchhoff's laws. The same result, however, may be attained in another manner quite independent of Kirchhoff's laws.

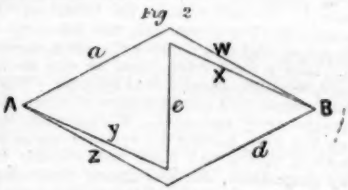
There are three paths for the current from A to B, Fig. 1. 1st, through a and c; 2nd, through b, e, and c; 3rd, through b and d. If these paths can be arranged

Fig. 1



so that each is independent of and separate from the others (as represented in Fig. 2), the question is reduced to the simple one of finding the combined resistance of three conductors.

Fig. 2



Imagine the sections b and c (Fig. 1), each split longitudinally into two conductors, and one of each connected, as shown in Fig. 2, to the ends of e. Call the two parts of c, w, and x, and the two parts of b, y, and z. The combined resistance of w and x must equal c, and that of y and z must equal b; from which the two following equations are obtained:

$$\frac{w\,x}{w+x} = c \quad (1)$$

$$\frac{y\,z}{y+z} = b \quad (2)$$

Again, the potential at the point of junction of z and d must be the same as at the junction of y and e. To effect this the resistance y must bear the same proportion to z as $e+x$ to d. This gives:

$$\frac{y}{z} = \frac{e+x}{d} \quad (3)$$

In the same manner the potential at the junctions of a with w and e with x being equal:

$$\frac{a}{y+e} = \frac{w}{x} \quad (4)$$

From these equations the following value of the unknown quantities w, x, y and z is obtained:

$$w = 3818\tfrac{3}{17}$$
$$x = 4200$$
$$y = 2300$$
$$z = 1769\tfrac{3}{13}$$

By substituting these values in Fig. 2 it will be evident that the question is simply to determine the joint resistance of three circuits, *i.e.*:

$$a + w = 6818\tfrac{3}{17}$$
$$y + e + x = 7500$$
$$z + d = 5769\tfrac{3}{13}$$

and the result is $2205\frac{1}{2}\frac{9}{3}$.

A. S. BROWN.

THE Eastern Extension, Australasia, and China Telegraph Company (Limited) have resolved to declare a final dividend of four shillings per share, making with the three interim dividends already paid, six and a half per cent for the year ending 31st December, 1874, free of income tax, carrying forward to reserve £32,839, making a total reserve of £75,453.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Vol. lxxx., No. 7. February 22, 1875.

New Researches on the Manner of Intervention of Electro-Capillary Forces in Nutrition Phenomena.—M. Becquerel.—We merely give the title, as the article is medical and not telegraphic.

On the Depth and Superposition of Magnetised Layers in Steel.—J. Jamin.—On December 30, 1872, and later, the author explained certain effects of inverse and direct currents of different intensities upon the same magnet by assuming that the magnetism only penetrates to a limited depth according to the strength of the current, and that the successive actions of the two currents (the first energetic and direct, the second weak and inverse) superpose two contrary magnetisations, the one deep, the other superficial. We only perceive the difference. As this conjecture has been contested, the following experiments, apparently of a decisive character, were undertaken. Into a steel tube, closed by two steel screw stoppers, was introduced a steel cylinder. The whole was magnetised in a coil by a current whose strength was progressively increased. Whilst weak it acted only on the tube, leaving the cylinder free as before; but with a determined force the cylinder became slightly magnetised, the magnetism increasing with the current strength until it attained the same power as that of the tube. To confirm this, the cylinder was first saturated alone with a direct current, and then introduced into the tube; then the whole concern was submitted (in a coil) to an intense and gradually-increasing current. Whilst the current was weak, the cylinder preserved all its magnetism; then, as the current strengthened, the cylinder slowly lost it, afterwards taking another of an inverse nature. There is always a moment in which the whole apparatus possesses no apparent magnetism, and cannot be magnetised by an inverse current, whilst it is energetically magnetised by the direct current which has magnetised the cylinder. But if the cylinder and tube together are thus neutral, it is not in a natural condition; for on separating the two portions, they have different magnetisms,—direct on the cylinder, inverse on the tube; they neutralise one another by super-position. This is what takes place in a single piece of steel when submitted to two contrary magnetisations. More direct methods of proof were instituted, consisting in dissolving the exterior parts of the magnets in diluted sulphuric acid. The results M. Jamin considers to be also conclusive, though the carrying out of the experiments was attended with great difficulties.

No. 8.

Contains no papers on electrical subjects.

No. 10. March 15, 1875.

Electro-Capillary Actions, and the Forces producing them.—M. Becquerel.—A thin platinum plate, full of a large number of small holes, is applied to each face of the permeable partition of an electro-capillary machine. These plates form the electrodes of the couples, inasmuch as they serve for conductors, being in contact with the damp sides of the partition. On the outer face of each of these plates wires of the same metal are fastened, and, including a very sensitive galvanometer, form a closed circuit. The magnetised needle is not deflected, a proof that all the electricity emitted under the reaction of the two liquids is transformed into an electro-capillary current without the intervention of a derived current—an effect contrary to that observed with voltaic currents traversing liquids. The conclusion to be deduced is, that the electro-capillary current, resulting from the reaction of the two solutions upon one another, produces a chemical action equal to that reaction. Numerous experiments prove that the stronger the electromotive force the more marked will be the electro-capillary actions.

On Determining the Quantity of Magnetism of a Magnet.—R. Blondlot.—Referring to M. Rothlauf's discussion in 1861 (*vide Annales de Poggendorff*), on Mr. Van Rees's method of investigating magnetic depth in magnets from its power of generating induced currents, the author declares the theory faulty in two points, and continues—"It may be interesting to examine, from a theoretical point of view, Mr. Van Rees's method; to seek out the exact signification of the numbers which it gives; and in particular to treat of one case where (though it be in general inexact) its application does not entail any appreciable error." The method in question is to insert in a coil, whose wire forms a closed circuit through a galvanometer, a bar magnet, and then sharply to withdraw it to a great distance: the strength of the induced current becomes the measuring quantity. The lesson learnt from the paper (of too mathematical a character for our columns) is that "in a long magnet the magnetism may be considered as accumulated in the neighbourhood of the extremities; consequently, if we place the coil upon the middle part of such a magnet afterwards withdraw it (the middle part) to a great distance, the conditions of the theory are sensibly enacted. Whence it results that the quantity of the current may serve to measure the total magnetism of the half of a bar, provided that it be not too short; that is to say, its distance should not be less than 8 to 10 centimetres. The current is also independent of the diameter of the coil, on condition that its diameter be a small fraction of the length of the bar."

On the Magnetising Function of Tempered Steel.—M. Bouty.—The magnetic moment of a needle may always be considered the product of two factors, one of which expresses the quantity of magnetism in the needle, or, if preferred, the strength of each pole,—whilst the other factor is equal to the distance of the two poles. The determination separately of these two distinct elements, and the study of the variation of each of them under changed magnetising conditions, occupied M. Bouty some time, and his investigations are still incomplete.

No. 11. March 22, 1875.

A New Electro-Medical Galvanoscope.—J. Morin.—Consists of an ordinary two-branch electro-magnet, placed vertically, the breach being in the air. A magnetic needle is suspended by one of its poles over the breach, through which it penetrates by means of a large hole. The lower free pole of the needle descends as far as the level of the lower part of the electro-magnet's helices, between which it is able to oscillate. The needle is long enough to penetrate the breach to the height of its neutral point, thus nullifying at that spot all reciprocal action. On making a current circulate in the helices the two poles act in the same direction upon the free pole of the magnetic needle, causing it to be displaced towards one of the helices according to the direction of the current. This apparatus is said to answer the purpose for which it has been devised.

On Magnetisation.—J. M. Gaugain.—A continuation of some former articles.

No. 12. March 29, 1875.

Contains no papers of interest to our electrical readers.

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This issue is entirely taken up with personal and other official matter.